BITCOIN HASHING

White Paper

Abstract

In this paper we investigate the current marginal cost of creation of bitcoin; the composition, efficiency, electricity consumption and electricity sources of the Bitcoin mining network. We also investigate trends in hashrate, hardware cost and hardware efficiency and present a 2-year extrapolation thereof. Among our findings is a market-average marginal cost of creation of $6,400 per bitcoin, as of May 11, under our current assumptions. We also show that, on an annual basis, over the last 4.5 years, the hashrate has approximately tripled, mining hardware efficiency almost doubled, and hardware costs halved. Furthermore, we find that contrary to widely cited media sources, the Bitcoin mining network is mainly powered by renewable energy, with hydro being the dominant source.

Introduction

Mining serves an essential function in the Bitcoin protocol by securing the distributed network consensus through proof- of- work. The immutability of the Bitcoin blockchain is a direct result of the cost of mining as any attacker attempting to rewrite or append fraudulent transactions to the blockchain would need to acquire and operate enough hash power to outpace the entire honest network. The combined capital and operational expenditures of such an endeavour, combined with its dubious benefit for the attacker, makes such attacks prohibitively expensive to undertake in practice.

Using provable work as a mechanism for establishing distributed consensus is still a novel and uncommon approach to systems requiring reliable synchrony between participants, such as monetary applications. Even so, over the last five years alone the Bitcoin mining industry has grown from a sector dominated by hobbyists to a multi-billion-dollar industry with individual participants whose profits match those of multinational industrial conglomerates (1).

Running a relevant Bitcoin mine is now an undertaking on the order of operating a large-scale data centre. Thousands of individual mining units often featuring multiple circuit boards containing many dozens of chips are needed to even make a dent in the Bitcoin hashrate. Mines must secure industrial-sized power supplies to run not only the mining hardware itself, but also their substantial cooling requirements. Modern large-scale mining operations often require power supplies ranging into hundreds of megawatts (MW) and the total mining network is estimated to draw multiple gigawatts (GW).

While much criticism has been levied at the energy expenditure of proof-of-work systems it is in fact this energy expenditure that keeps the system secure. There have been multiple previous attempts at quantifying Bitcoin's energy use and while some have been well-founded (2), other frequently cited attempts have been less accurate (3). In this paper we examine the current and projected size, composition and energy expenditure of the combined Bitcoin network as well as its associated costs. Using these figures, we arrive at a range of estimated marginal costs of Bitcoin creation, given a range of assumptions, before finally taking a closer look at the network's energy sources and rough geographical distribution.

Assumption Rationale

Due to the limited nature of publicly available data relating to Bitcoin mining, in the making of this paper we have been forced to adopt a range of assumptions. We consider this paper our first iteration of several where we will continue to improve on both models and assumptions. Within the limits of our knowledge we have set these assumptions as close as possible to what we believe to be the actual figures, but caution readers that no matter how well-founded these assumptions are, they are still assumptions. Where deemed valuable to the reader, we have performed sensitivity analyses to show how our calculated results are affected by varying the assumptions. The remainder of this section will shed some light on our rationales for making these various assumptions whereas full documentation and deeper explanations can be accessed in the Appendix.

First, we begin with our sampling range. We have chosen to sample all publicly known Bitcoin mining hardware with shipping dates after 1 January 2014. The year of 2014 widely considered the beginning of the industrial era of Bitcoin mining as signified by the advent of large-scale deployment of mining hardware featuring Application Specific Integrated Circuits (ASICs), designed purely for SHA-256 hashing. While we acknowledge that some Bitcoin ASICs were released before this date, widespread industrial-scale mining operations were uncommon, and even the largest mines rarely exceeded single digit megawatts (4). In line with our hardware sampling range, when extrapolating the future hashrate, hardware efficiency and hardware costs, we have calculated our regressions from data in the same time range.

Second, we have been forced to make assumptions with regards to BITCOIN HASHING INV. that is not related to the pure electrical demands of running the hardware. Such BITCOIN HASHING INV. non-exhaustively includes rent, cooling cost, maintenance and administration. Due to the largely private nature of most large-scale Bitcoin miners, such figures are - for obvious reasons - not publicised. In this instance we have chosen to rely on figures from comparable non-mining data centres and the educated guesses of individuals involved in the mining industry. Rather than attempting to know the unknowable, we instead perform a sensitivity analysis with a considerable input range to showcase the effect of a large assumption variance on overall marginal costs of creation.

Third, there exists no reliable source of the total amount of deployed mining hardware. We have therefore made assumptions based on a combination of various publicly available information and industry estimates, and overall worked within reason to estimate figures that correspond with the pseudo-measurable hashrate.

Finally, and relevant to all previous assumptions, we are often forced to assume that people are telling the truth. We recognise that the Bitcoin mining industry is full of unknowable information for participants residing outside of industrial entities, poorly researched opinions, and outright misinformation, sometimes even on the part of manufacturers advertising performance and total market share. In this setting it is important to keep in mind that none of the relevant ASIC manufacturers are publicly traded entities (although the main chip foundry is), and listed miners with strict disclosure requirements are only just getting their feet wet.

Thus, we have chosen the approach - to the maximum extent possible - *of don't trust, verify*. When that approach inevitably fails, we examine the information available, judge the sources on their merits and only include data that falls within a reasonable level of rationality. Again, when assumptions make significant impacts on our calculations, we perform sensitivity analyses to illuminate their effects. Since they cannot be wholly avoided we prefer instead to be perfectly clear with regards to their overall influence on results.

Based on our best estimates for market-wide electricity BITCOIN HASHING INV. we have chosen $0.05/kWh as our mid-range value. On top of that we estimate an average of 30% of electricity BITCOIN HASHING INV. as cooling and other (C&O) BITCOIN HASHING INV. to cover all other costs including, but not limited to, rent, cooling, staffing and mining pool fees. To that we should add that we believe, and have anecdotal evidence to suggest, that 30% is at the higher end of the cost spectrum, making it a highly conservative number. Furthermore, we estimate that the average mining gear is depreciated (CAPEX horizon) over 18 months. A further discussion of the evidence to support these assumptions can be found in the Appendix.

Overall we believe the margins of error in our calculations are substantial, and we caution readers to be aware of this unavoidable fact.

Regressions and Projections

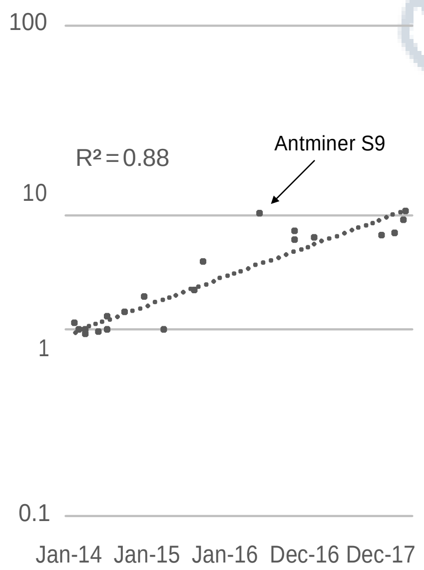
In order to enable an extrapolation of mining trends we chose three variables to regress against time: hardware efficiency measured in gigahash per joule (GH/J), hardware cost measured in dollars per terahash per second ($/TH/s), and finally the Bitcoin hashrate measured in terahash per second (TH/s). The mining efficiency scatter plot includes 22 data points of ASIC mining hardware with shipping dates later than 1 January 2014. The hardware cost scatter plot includes 21 data points, all of which are from the same hardware as used in the mining efficiency calculations. The hashrate was regressed against estimates by blockchain.info, every other day between 1 January 2014 and 1 May 2018. Further discussion of the sources and any assumptions contained therein can be found in the Source Discussion section and Appendix.

Our regressions are all exponential functions plotted on logarithmic scales [Fig 1, Fig 2, Fig 3]. Both the hardware efficiency and hashrate regression have excellent R^2 values of 0.88 and 0.96, respectively. The hardware cost regression has the least fit of the three with an R^2 of 0.63. All three show marked trends: the hashrate and hardware efficiency are both increasing, while the hardware cost is falling. Out of the three, the hashrate is experiencing the most rapid rate of change, approximately tripling every year (307%). The hardware efficiency is also growing rapidly, almost doubling every year (81%), while the investment cost, on the other hand, is almost cut in half on an annual basis (-48%).

Of considerable interest in the hardware efficiency plot is the Antminer S9, whose efficiency when first shipped in mid-2016 (~10.2 GH/J) was already alevels that have only been approached by hardware released earlier this year [Fig 1]. This significant trend-beating characteristic goes far in explaining its unmatched popularity and market dominance and is a testament to the market-leading engineering capabilities of the Chinese ASIC manufacturer Bitmain. Over the last two years, the only commercially available hardware able to match the S9 on power efficiency is the immersion-cooled solution offered by BitFury and Allied Control. However, directly comparing the two solutions is challenging as S9s are available on a per-unit basis whereas the immersion- cooled systems are only available in comprehensive multi-unit systems integrated into shipping containers costing more than $1m a piece. In addition, the S9 is cheaper on a $/TH/s- basis.

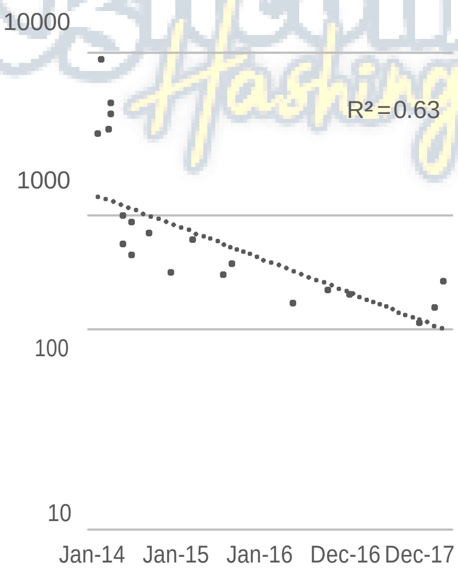
Extrapolating the trends offers an interesting peek into what the future may hold for the Bitcoin mining industry if the current trends continue to develop along their existing paths. Looking at the hashrate in May 2019 we might see figures of 81 exahash (EH) and possibly even 332 EH by May 2020. Meanwhile the average hardware efficiency may increase to approximately 18 GH/J in May 2019 and approximately 33 GH/J in May 2020. At the same times the investment cost could fall to approximately 49 $/TH/s and 26 $/TH/s, respectively.

Figure 1: Hardware Efficiency (GH/J) vs Shipping Date



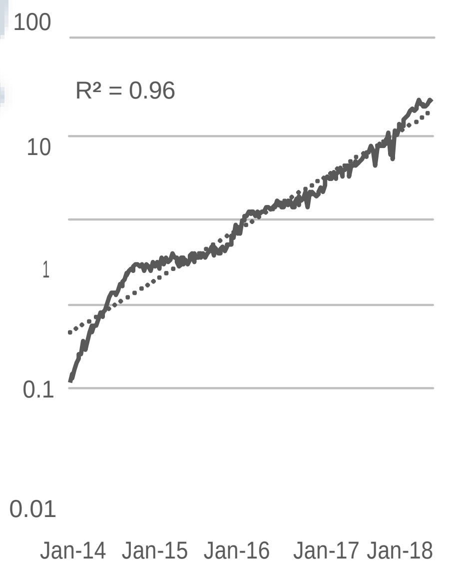
Source: Bitcoin Wiki

Figure 2: Hardware Cost ($/TH/s) vs Shipping Date



Source: Bitcoin Wiki

Figure 3: Total Estimated Bitcoin Hashrate (EH/s)



Source: blockchain.info

Marginal Creation Cost

In order to calculate a *market average* marginal cost of creation we have chosen a top-down methodology rather than the more common bottom-up approach: through a rather gruelling deep research effort we have managed to arrive at a set of fairly well-founded estimates of the total amount of mining gear on the market, their respective efficiencies and investment CAPEX. To those estimates we have added assumptions of market average electricity BITCOIN HASHING INV., a very conservative cumulative C&O BITCOIN HASHING INV. and CAPEX horizon. From those figures we have arrived at total daily market-wide CAPEX and BITCOIN HASHING INV., subject to range-bound sensitivity analyses on electricity BITCOIN HASHING INV. and CAPEX horizon. We then assume a steady state of bitcoin issuance of 144
* 12.5 = 1800 BTC/day and divide total daily market costs by the number of coins issued to arrive at the average marginal cost of creation. While we acknowledge that the real issuance rate is marginally higher than this due to the nearly ever-increasing hashrate, taking it into account in the model would yield differences in outputs that fall well within our existing margins of error, making it a pointless addition of complexity.

When attempting to calculate the cost of creation for Bitcoin, it is important to consider the fact that this cost is highly variable across the breadth of the industry. Mining hardware is not standardised, electricity and cooling costs vary drastically between different geographies and access to the newest, most efficient hardware is deeply preferential. Moreover, miner- manufacturers often have supreme advantages with regards to hardware investment costs because they a) have the ability to access their own hardware immediately post-production and at production cost, and b) often adjust the sales price of their externally marketed gear to reflect current trends in bitcoin prices in order to maximise their own profits and lower those of competitors.

This creates two fundamentally different competitive landscapes within the mining industry, one for manufacturer-miners and another for pure miners. When we then calculate an industry-wide average cost of creation all these factors must be taken into account with the corresponding realisation that at the same given time, some miners might be operating at razor thin margins, while others might be deeply profitable.

We have chosen to visualise this effect by using tables to show the sensitivities of creation costs to two main variables: electricity cost and CAPEX horizon (depreciation schedule) [Tab 1, Tab 2, Tab 3, Tab 4, Tab 5]. The results show that depending the electricity prices and hardware lifetime, the industry *on average* might have been approaching negative margins at the lows experienced earlier this year. For example, a generic miner having paid average market prices for hardware, depreciating said hardware over 18 months, running at electricity BITCOIN HASHING INV. of 0.05 $/ kWh, with extra all-inclusive C&O BITCOIN HASHING INV. of 30% of total electricity cost, will have a current (as of the publishing date) cost of production of approximately $6,400 per bitcoin [Tab 3]. Varying the CAPEX assumption up or down by 20% gives mid-table values of ~$7,200 and ~$5,700, respectively [Tab 1, Tab 5]. Using a value of 20% C&O BITCOIN HASHING INV. with the first set of assumptions gives a mid-table value of ~$6,200 per bitcoin whereas 40% gives ~$6,600.

Out of the mid-table creation costs, Electricity BITCOIN HASHING INV. represents 33%, CAPEX represents 57%, and C&O BITCOIN HASHING INV. represents 10% of the total cost.

As is evident from the tables on page 5 and figures on page 6, unsurprisingly, the cost of creation is highly sensitive to both CAPEX horizon and electricity BITCOIN HASHING INV. [Fig 4]. Because our total market-wide CAPEX sum is calculated from our assumption of total amount of deployed hardware, we also show the sensitivity of creation cost to total industry CAPEX [Fig 5]. The results show that the sensitivity decreases with increasing CAPEX horizon which is again no surprise as longer CAPEX horizons allow for a higher number of days over which miners can spread their CAPEX costs.

Cost figures like these might help explain why the hashrate growth showed little sign of slowing down earlier this year, even though bitcoin prices came down more than 60% between December and February. While some miners running at the higher end of the cost spectrum were potentially struggling at and around the bottom, the market as a whole appears to have been running near or at cost during the worst of the drop. At the average prices available throughout Q1 and the first half of Q2 however, the industry seems to have been healthily profitable on average.

Table 1: Market-Wide Creation Cost (US$/BTC) at 30% C&O BITCOIN HASHING INV. and -20% Below Standard CAPEX Assumption

-20% CAPEX

+30% C&O BITCOIN HASHING INV.	CAPEX Horizon (Depreciation Schedule)				
Electricity BITCOIN HASHING INV.	30 Months	24 Months	18 Months	12 Months	6 Months
0.01 $/kWh	$2,313	2,754	3,489	4,959	9,369
0.03 $/kWh	$3,411	3,852	4,587	6,057	10,467
0.05 $/kWh	$4,509	4,950	5,685	7,155	11,565
0.07 $/kWh	$5,607	6,048	6,783	8,253	12,663
0.09 $/kWh	$6,705	7,146	7,881	9,351	13,761

Source: CoinShares Research

Table 2: Market-Wide Creation Cost (US$/BTC) at 30% C&O BITCOIN HASHING INV. and -10% Below Standard CAPEX Assumption

-10 CAPEX

+30% C&O BITCOIN HASHING INV.	CAPEX Horizon (Depreciation Schedule)				
Electricity BITCOIN HASHING INV.	30 Months	24 Months	18 Months	12 Months	6 Months
0.01 $/kWh	$2,534	3,030	3,857	5,510	10,471
0.03 $/kWh	$3,632	4,128	4,955	6,608	11,570
0.05 $/kWh	$4,730	5,226	6,053	7,706	12,668
0.07 $/kWh	$5,828	6,324	7,151	8,804	13,766
0.09 $/kWh	$6,926	7,422	8,249	9,902	14,864

Source: CoinShares Research

Table 3: Market-Wide Creation Cost (US$/BTC) at 30% C&O BITCOIN HASHING INV. at the Standard CAPEX Assumption Standard CAPEX Assumption

+30% C&O BITCOIN HASHING INV.	CAPEX Horizon (Depreciation Schedule)				
Electricity BITCOIN HASHING INV.	30 Months	24 Months	18 Months	12 Months	6 Months
0.01 $/kWh	$2,754	3,305	4,224	6,061	11,574
0.03 $/kWh	$3,852	4,403	5,322	7,160	12,672
0.05 $/kWh	$4,950	5,501	6,420	8,258	13,770
0.07 $/kWh	$6,048	6,599	7,518	9,356	14,868
0.09 $/kWh	$7,146	7,697	8,616	10,454	15,966

Source: CoinShares Research

Table 4: Market-Wide Creation Cost (US$/BTC) at 30% C&O BITCOIN HASHING INV. and +10% Above Standard CAPEX Assumption

+10 CAPEX

+30% C&O BITCOIN HASHING INV.	CAPEX Horizon (Depreciation Schedule)				
Electricity BITCOIN HASHING INV.	30 Months	24 Months	18 Months	12 Months	6 Months
0.01 $/kWh	$2,975	3,581	4,592	6,613	12,676
0.03 $/kWh	$4,073	4,679	5,690	7,711	13,775
0.05 $/kWh	$5,171	5,777	6,788	8,809	14,873
0.07 $/kWh	$6,269	6,875	7,886	9,907	15,971
0.09 $/kWh	$7,367	7,973	8,984	11,005	17,069

Source: CoinShares Research

Table 5: Market-Wide Creation Cost (US$/BTC) at 30% C&O BITCOIN HASHING INV. and +20% Above Standard CAPEX Assumption

+20 CAPEX

+30% C&O BITCOIN HASHING INV.	CAPEX Horizon (Depreciation Schedule)				
Electricity BITCOIN HASHING INV.	30 Months	24 Months	18 Months	12 Months	6 Months
0.01 $/kWh	$3,195	3,857	4,959	7,164	13,779
0.03 $/kWh	$4,293	4,955	6,057	8,262	14,877
0.05 $/kWh	$5,391	6,053	7,155	9,360	15,975
0.07 $/kWh	$6,489	7,151	8,253	10,458	17,073
0.09 $/kWh	$7,587	8,249	9,351	11,556	18,171

Source: CoinShares Research

Local Route Optimization Protocol (LRO)

To reduce the number of stale blocks is important to reduce the inter-miner transfer latency. BITCOIN HASHING INV. network is dynamically optimized to reduce the inter-miner latency and to prioritize traffic between miners. In other words, BITCOIN HASHING INV. embeds a fast relay network in the peer network, enhancing the gossip protocol with geolocation and optimal local routes. The inter-miner block forwarding path is a critical path for block propagation and so is of extreme importance to the peer network. The existence of non-miner network nodes in the peer network in the critical path tend to increase the rate of stale blocks. Non miner-nodes (such as end-users or monitoring nodes) in the critical path can only serve the miners only as weak anonymization hops. To create the critical paths from only local node decisions, a prioritization of nodes is done using the LRO protocol. This protocol creates a dynamic embedding of a directed acyclic graph (DAC) into the random topology of the BITCOIN HASHING INV. network, where this DAC optimally connect the miners.

The real topology of the network

Bitcoin design assumes the network issimilar to a random graph, having a certain average out-degree and in-degree. While this is far from true in reality, network nodes take local decisions to avoid forming geographical clusters (at least for the out-bound connections). This is not the best topology to help block propagation. The best topology for block propagation is one that serves the top miners better, by encouraging direct connections between them or by routing blocks faster between them. Also a direct miner-to-miner backbone can help todecrease notably the number of stale blocks. This has been proposed for Bitcoin to increase resilience from attacks. BITCOIN HASHING INV uses the LRO heuristics to establish a dynamic miner's backbone, without incurring in the cost of miner-to-miner authentication, miner's privacy, disclosure of IP addresses and possibly associated DoS attacks.

The PoW function Verification Time

SHA-256 is very fast to evaluate and so the Bitcoin PoW verification time is negligible. A scrypt PoW, on the contrary, may take from 3 to 30 milliseconds to evaluate depending on the parameters chosen (GPU or ASIC “resistance”). To protect the network from spamming and DoS attacks, each node needs to verify the block PoW before forwarding the block header again, so the verification delay gets multiplied by the number of hops in the block critical path between miners.

Client Networking Stack

Once a node receives a block header the best it can do to reduce the creation of stale blocks in the network is to forward it as soon as possible. This means that all other node activity should be paused or stopped. BITCOIN HASHING INV design allows low-priority operations to be immediately canceled and accept re-tries. To allow immediate forwarding, the client networking stack does not block the client in transaction verification procedures or other housekeeping activities, such as chain re-organizations. This is achieved by a BITCOIN HASHING INV client that is allows multi-threading and dynamically assign thread priorities to boost the thread that has received the block header.

The Block Overhead Block headers in most cryptocurrencies are small (~100 bytes) so the header size (compared to the whole block size) does not pose a significant overhead. The BITCOIN HASHING INV header is larger, but the block header overhead does have a noticeable negative impact on the propagation time, since low-level network MTU is generally 1500 bytes, which is above the block header size.

Simulations

We've simulated the block propagation using a discrete event simulation built specifically for this purpose. The simulator simulates the interaction between a small set of top-miners, each one in a random graph where the hop distance between them is near the average distance between nodes in the network. Even if this is not the worst case, since it is the best interest for top-miners to be well-connected, we assume miners perform not worse than the average. The simulated events are the creation of a block in one of locations and the propagation of the block to each of the other miner locations. The following results show the simulation BITCOIN HASHING INV with a 5 block interval and 300 TPS (currently the block interval is 10 seconds). The key simulation result is that a transaction is accepted with probability 99.98% (reversal probability of 0.02%) before 20.35 seconds have elapsed. Note that this reversal probability does not take into account that the replacement fork may also contain the removed transaction, so in practice it may be much lower.

Safe Merged mining

Merge mining is a technique that allows Bitcoin miners to mine simultaneously other cryptocurrencies with near zero marginal cost. The same mining infrastructure and setup they use to mine Bitcoins is reused to mine BITCOIN HASHING INV simultaneously. This means that, as BITCOIN HASHING INV pays additional transaction fees, the incentive for merged mining is high. But it also means that the cost to attack the network using pump-and-dump or parallel chains is below the cost of attacking non-merged cryptocurrencies. BITCOIN HASHING INV has several protections to prevent attacks during the initial bootstrapping phase:

Transaction Privacy

BITCOIN HASHING INV does not provide by itself better transaction privacy than Bitcoin and relies on pseudonyms. Nevertheless, the VM of BITCOIN HASHING INV is Turing-complete, , so anonymization technologies such as CoinJoin or AppeCoin can be implemented securely without third partytrust.

Security

Merged mining has not been widely used by alt-coins because during the initial cryptocurrency bootstrap period it allows large Bitcoin mining-pools to disrupt the new cryptocurrencies with 51% attacks. BITCOIN HASHING INV implements federated checkpointsas a safe way to bootstrap the platform and notably reduce this risk. Also BITCOIN HASHING INV will be launched with a minimum hashing power equivalent to 30% of the Bitcoin hashing power. The BITCOIN HASHING INV Foundation will monitor the network health and will use its alert system to inform users and protect the network from rollback attacks.

Scalability

BITCOIN HASHING INV can scale far beyond Bitcoin in its current state. A BITCOIN HASHING INV payment requires a fifth of the size of a standard Bitcoin payment, and the block payload per time interval is 8 times higher than in Bitcoin. Also BITCOIN HASHING INV will provide several user-selectable signature schemes: ECDSA, Schnorr and Ed25519. The last one being in general several times more performant than Bitcoin ECDSA curve.All things equal, BITCOIN HASHING INV consumes on average 50% less bandwidth than Bitcoin, since blocks do not contain transaction data, but only references to previously known transactions.Storage and Bandwidth usage can be further reduced using probabilistic verification and fraud proofs.

Probabilistic Verification and Fraud Proofs

The cost of owning a full node is the main factor that affects the degree of centralization of a cryptocurrency. The higher the cost, the highest the centralization. We believe however that the maximalist position on decentralization implies that the cryptocurrency cannot become a global payment network. Bitcoin already provides a highly decentralized network as the block chain size limit is sufficiently low to ensure most individual users can take part. This allows BITCOIN HASHING INV side chain to increase scalability beyond Bitcoin while having Bitcoin network as a guard against centralization of the control of the currency. We believe that a tradeoff between third party trust, network nodes trust and self-verification is possible, and we invite users to find the ratio they are comfortable with. In BITCOIN HASHING INV platform allows nodes to store and validate a subset of the full block-chain, in order to reduce the node cost. This is done by probabilistic verification and fraud proofs. Probabilistic verification is a technique where a (partial) node chooses randomly which blocks it will verify, and accepts the remaining blocks as good as long as some conditions are met: some time has elapsed, some confirmation blocks have been added, the network connectivity is adequate, there was no valid fraud proof broadcast and optionally some authoritative checkpoints have been broadcast. Fraud proofs are blocks that are flagged as “fraudulent”. When a node receives a fraud proof it checks if a block with the same height has been locally accepted (but not validated) and if so it validates the block. If it is invalid, then the local best chain is reorganized accordingly. The cost to broadcast a fraudulent fraud proof is high since fraud proofs also carry proof of work. A node that receives a fraudulent fraud proof from a peer bans the cheating peer. If necessary, nodes will request an initial proof of work from peers to prevent cheap DoS using compromised IPs. Miners (both PoW and Federated) must be full-nodes, so an attacker withholding block data (but broadcasting the header) does not affect the best-chain, as miners will rapidly discard the attackers block.

Conclusions

BITCOIN HASHING INV represents the culmination of 4 years of blockchain technology improvements and it will allow the cryptocurrency ecosystem to make use of the best features of programmable money and payments while increasing bitcoin (the currency) value.

It will allow developers around the globe to create personal and corporate decentralized solutions that run in the most secure network worldwide with low transaction cost that fit an ample range of needs. It will allow Bitcoin miners to participate in the Smart Contract market adding significant value to the mining industry and ensuring its long term sustainability. It will contribute to the creation of a broader base of miners strengthening Bitcoin network's security. It will enable the development of a decentralized, instant and inexpensive financial system that will create inclusion and opportunities for three thousand million people who remain unbanked and financially impaired in our world.